Spatiotemporal Chaos in Rotation Profiles near Separatrix of Tokamak Plasma

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Toroidal and poloidal rotations of plasma at the edge region of tokamak devices have long been known to play an important role, such as enhancing the confinement properties by suppressing turbulent behaviour, improving tolerance to error fields and increasing stability to neoclassical tearing modes [1]. This behaviour is seen in many tokamaks with different regimes. Imparting momentum to the plasma is also possible intrinsically as well as through the external sources such as, for example, the neutral beam injection. Several mechanisms has been suggested to explain the reason for spontaneous toroidal rotation of plasmas. The gradients of temperature and density have also an effect on plasma rotation. Therefore, the bifurcations and chaos in temperature profiles caused by a periodically driven impurity injection in edge region of toroidal devices [2] are also likely to influence the rotation phenomena. Hence, understanding of creation and evolution of rotation has a great importance, since external momentum would not be enough or could not be even realized especially for future large fusion devices [3].

In this study, the flux surface averaged toroidal and poloidal plasma rotation equations in edge region of tokamak have been investigated numerically by using a discretization method described in Ref. [4] within the context of collisional neoclassical theory revised to include the effects of steep gradients [5-8] with nonchaotic magnetic fields. For the temperature and density evolutions the multi-time scale quasilinear energy and particle conservation equations were considered conjointly with the toroidal and poloidal rotation velocity equations derived from the conservation of angular momentum. These equations were solved in a radial boundary layer of the magnetic separatrix under the Dirichlet boundary conditions.

It is shown that the approach of the inital gradient of temperature and density to a steady-state is much faster than those of the rotation velocities. Under some boundary values, however, it is observed that, in particular the poloidal rotation has a tendency for spatiotemporal chaotical oscillations. This is due to the weakening of the stability of the system of equations considered. It is observed that as the initial steepness of the temperature and density gradients grows, the velocity profiles exhibit bifurcative behaviour as shown in steady state solutions [9]. A special diffusively coupled map lattice was also applied as a model for the chaotic solutions of the PDE system considered.

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